Within linguistics a word class is defined in grammatical terms as a set of words that exhibit the same syntactic properties. In this paper the aim is to argue that the meanings of different word classes can be given a cognitive grounding. It is shown that with the aid of conceptual spaces, a geometric analysis can be provided for the major word classes. A universal single-domain thesis is proposed, saying that words in all content word classes, except for nouns, refer to a single domain.

**Keywords**: Conceptual spaces, cognitive semantics, word classes, single domain, convexity, noun, adjective, verb, preposition, adverb.

1. **Cognitively grounded semantics**

What is it that you know when you know a language? Certainly you know many words of the language—its lexicon; and you know how to put the words together in an appropriate way—its syntax. More importantly, you know the meaning of the words and what they mean when put together into sentences. In other words, you know the semantics of the language. If you do not master the meaning of the words you are using, there is no point in knowing the syntax. Therefore, as regards communication, semantic knowledge is more fundamental than syntactic. (I am not saying the syntax does not contribute to the meaning of a sentence, only that without knowledge of the meanings of the basic words there is no need for syntax.)

In Gärdenfors (2014), I connect the semantics of various forms of communication to other cognitive processes, in particular concept formation, perception, attention, and memory. As Jackendoff (1983: 3) puts it: “[T]o study semantics of natural language is to study cognitive...”

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1 This article is, to a large extent, a summary of material in Part 2 of Gärdenfors (2014).
psychology”. My theoretical starting point is that our minds organize the information that is involved in these processes in a format that can be modelled in geometric or topological terms—namely in conceptual spaces. The theory of conceptual space was presented in an earlier book (Gärdenfors 2000). My general semantic program is to show that by using conceptual spaces, a unified theory of word meanings can be developed.2

Most researchers within semantics look at the meaning of words from a linguistic perspective. From this perspective it is difficult to free oneself of syntactic concepts. For example, the “arguments” of verbs show up in most semantic analyses (for example, Levin and Rappaport Hovav 2005). The notion of argument derives, however, from syntax. Among other things, this leads to the distinction between transitive and intransitive verbs. However, this distinction does not correspond to any clear-cut semantic distinction. Similarly, it is said that verbs and adjectives are used in a “predicative” manner. The notion of predicative derives from theories in philosophy and linguistics that aim at grounding semantics in predicate logic. In my opinion, this is an artificial construction that does not have a cognitive grounding. In contrast, my ambition is to develop semantic models that are constructed from general cognitive mechanisms. The semantic theory of this article is supposed to be syntax-free. In other words, the semantic notions should not depend on any grammatical categories. This does not mean that I deny that syntax contributes to meaning (Langacker 2008: 3–4). I only claim that semantics of word roots can be treated independently from syntax.

2. The semantics of word classes

One of the most fundamental concepts of linguistics is that of word classes. In all languages, words can be grouped in distinct classes with different semantic and syntactic functions.3 In English the words have traditionally been classified into eight classes: nouns, pronouns, adjectives, verbs, adverbs, prepositions, conjunctions, and interjections.4 When word classes are taught at an introductory level in school, semantic criteria are used, for example that nouns stand for things and verbs describe actions, but these criteria are seldom presented in a systematic and rigorous way.

In contrast, within linguistics a word class is defined in grammatical terms as a set of words that exhibit the same syntactic proper-

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2 In linguistics, the appropriate word for “word” is “part of speech”. When I use “word”, I normally mean “word stem”, since I will not be concerned with morphology.

3 There are other opinions: Gil’s (1994) work on Riau Indonesian suggests that it has no distinctions between different kinds of words.

4 There exist, however, other identifiable word classes, for example, numerals and articles.
ties, especially concerning inflections and distribution in sentences. I do not believe in a universal definition of word classes (cf. Croft 2001, ch. 3). Syntactic structure, including the division into word classes, is language-specific. However, one can identify prototypical structures among words that can be used in classifications. Croft (2001: 63) writes: “Noun, verb, and adjective are not categories of particular languages ... [b]ut noun, verb, and adjective are language universal—that is, there are typological prototypes ... which should be called noun, verb, and adjective.” In contrast, my position is that the syntactic markers have evolved as effects of the divisions of words into categories, not as causes.

The fact that major word classes such as verbs, nouns, and adjectives can be identified in almost all languages suggests that there are universal patterns in human cognition that make the division into these classes particularly useful for communication (Dixon 2004). The structure of communication is subject to the same cognitive constraints as thinking and problem solving in general. Therefore it is reasonable that the structure of language, at least to some extent, is determined by such general cognitive principles. In particular, I assume that the structure of language is governed by the same principles of processing efficiency of representations as are other cognitive processes.

I do not claim that there is any simple mapping between word classes and structures in conceptual spaces. As an illustration, Dixon (2004: 2) writes: “[A] lexical root cannot be assigned to a word class on the basis of its meaning. If this were so, then ‘hunger/(be) hungry’, ‘(be) mother (of)’, ‘(be) two’, and ‘beauty/(be) beautiful’ would relate to the same class in every language, which they do not.” Dixon also points out that the concept of ‘needing to eat’ is expressed as nouns, adjectives, or verbs in different languages and that mother and father are verbs in some American Indian languages. Nor do words (word roots) necessarily belong to particular word classes. An example from English is round, which can be used as adjective, noun, verb, adverb, and preposition.

In this paper the focus will be on showing how the meanings of different word classes can be given a cognitive grounding. I will expand on the analysis of nouns and adjectives that I outlined in Gärdenfors (2000). Before embarking on that project, however, I will briefly present conceptual spaces.

3. Conceptual spaces as a semantic framework

A conceptual space consists of a number of quality dimensions. Examples of quality dimensions are temperature, weight, brightness, pitch, and force, as well as the three ordinary spatial dimensions of height, width, and depth. Some quality dimensions are of an abstract non-sensory character. In Gärdenfors (2014), I argue that force dimensions are essential for the analysis of actions and events and thereby for the semantics of verbs.
Quality dimensions correspond to the different ways stimuli can be judged similar or different. For simplicity, I assume that the dimensions have some metric, so that one can talk about distances in the conceptual space. Such distances indicate degrees of similarity between the objects represented in the space.

It is further assumed that each of the quality dimensions can be described in terms of certain geometrical structures. A psychologically interesting example is colour. Our cognitive representation of colour can be described along three dimensions. The first is hue, represented by the familiar colour circle going from red to yellow to green to blue, then back to red again. The topology of this dimension is thus different from the quality dimensions representing time or weight, which are isomorphic to the real number line. The second dimension is saturation, which ranges from grey at the one extreme, to increasingly greater intensities of colour at the other. This dimension is isomorphic to an interval of the real number line. The third dimension is brightness, which varies from white to black, and thus is also isomorphic to a bounded interval of the real number line. Together, these three dimensions—one circular, two linear—constitute the colour domain as a subspace of our perceptual conceptual space. It is typically illustrated by the so-called colour spindle.

The primary function of the dimensions is to represent various qualities of objects in different domains. Since the notion of a domain is central to the analysis, I should give it a more precise meaning. To do this, I will rely on the notions of separable and integral dimensions, which I take from cognitive psychology (Garner 1974, Maddox 1992, Melara 1992). Certain quality dimensions are integral: one cannot assign an object a value on one dimension without giving it a value on the other(s). For example, an object cannot be given a hue without also giving it a brightness (and a saturation). Likewise the pitch of a sound always goes with a particular loudness. Dimensions that are not integral are separable: for example, the size and hue dimensions. Using this distinction, a domain can now be defined as a set of integral dimensions that are separable from all other dimensions.

A conceptual space can then be defined as a collection of quality dimensions divided into domains. However, the dimensions of a conceptual space should not be seen as fully independent entities. Rather, they are correlated in various ways, since the properties of those objects modelled in the space co-vary. For example, in the fruit domain, the ripeness and colour dimensions co-vary.

It is impossible to provide any complete listing of the quality dimensions involved in the conceptual spaces of humans. Learning new concepts often means expanding one’s conceptual space with new quality dimensions (Smith 1989).
4. Properties and concepts

Conceptual spaces theory will next be used to define a *property*. The following criterion was proposed in Gärdenfors (1990, 2000), where the geometrical characteristics of the quality dimensions are used to introduce a spatial structure to properties:

**Criterion P:** A property is a convex region in some domain.

The motivation for criterion $P$ is that, if some objects located at $x$ and $y$ in relation to some quality dimension(s) are both examples of a concept, then any object that is located between $x$ and $y$ with respect to the same quality dimension(s) will also be an example of the concept. This is the definition of convexity.

Properties, as defined by criterion $P$, form a special case of *concepts*. I define this distinction in Gärdenfors (2000) by saying that a property is based on a single domain, while a concept is based on one or more domains. This distinction has been obliterated in both symbolic and connectionist accounts, which have dominated the discussions in cognitive science. For example, both properties and concepts are represented by predicates in first-order logic. However, the predicates of first-order logic correspond to several different word classes in natural language, most importantly those of adjectives, nouns, and verbs.

A paradigm example of a concept that is represented in several domains is “apple” (compare Smith et al. 1988). One of the first problems when representing a concept is to decide which are the relevant domains. When we encounter apples as children, the first domains we learn about are, presumably, those of colour, shape, texture, and taste. Later, we learn about apples as fruits (biology), about apples as things with nutritional value, etc.

The next problem is to determine the geometric structure of the domains: i.e., which are the relevant quality dimensions. Taste space can be represented by the four dimensions of sweet, sour, salty, and bitter; the colour domain by hue, saturation, and brightness. Other domains are trickier. For example, it is difficult to say much about the topological structure of “fruit space”, in part because fruits (such as apples) can be described relative to several domains. Some ideas about how such “shape spaces” should be modelled have been discussed in e.g. Marr and Nishihara (1978), Edelman (1999), and Gärdenfors (2000). Instead of offering a detailed account of the structures of the different domains, let me represent the “apple” regions in the domains verbally, as follows:

<table>
<thead>
<tr>
<th>Domain</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>colour</td>
<td>red-yellow-orange</td>
</tr>
<tr>
<td>shape</td>
<td>roundish</td>
</tr>
<tr>
<td>texture</td>
<td>smooth</td>
</tr>
<tr>
<td>taste</td>
<td>regions of the sweet and sour dimensions</td>
</tr>
<tr>
<td>nutrition</td>
<td>values of sugar content, fibre content, vitamins, etc.</td>
</tr>
<tr>
<td>fruit</td>
<td>specification of seed structure, fleshiness, peel type, etc.</td>
</tr>
</tbody>
</table>
Concepts are not just bundles of properties. They are also correlations between regions from different domains that are associated with the concept. The “apple” concept has a strong positive correlation between sweetness in the taste domain and sugar content in the nutrition domain, and a weaker positive correlation between redness and sweetness. Such considerations motivate the following definition for concepts.\(^5\)

**Criterion C:** A concept is represented as a set of convex regions in a number of domains, together with information about how the regions in different domains are correlated.

Elements from theories in psychology and linguistics contribute to the analysis of concepts I present here. The kind of representation intended by Criterion C is, on the surface, similar to frames, with slots for different features. Frames have been very popular within cognitive science as well as in linguistics and computer science. However, Criterion C is richer than frames, since it allows representing concepts as more or less similar to each other and objects (instances) as more or less representative of a concept. Conceptual spaces theory can be seen as combining frame theory with prototype theory, although the geometry of the domains makes possible inferences that cannot be made in either of those theories (Gärdenfors 1990, 2000).

The distinction between properties and concepts is useful for analysing the cognitive role of different word classes. In brief, I propose that the main semantic difference between adjectives and nouns is that adjectives like red, tall, and heavy typically refer to a single domain and thus represent properties, while nouns like dog, apple and car contain information about several domains and thus represent object categories. Next, I will look closer at these proposals.

## 5. Nouns

In informal definitions of nouns, it is said that they refer to things: objects, persons, places, events, substances, etc. However, linguists are in general not satisfied with this kind of description, since it is difficult to specify a complete list of categories. Furthermore, the definition uses abstract nouns to define the very notion of a noun, which makes it slightly circular.

There also exist abstract nouns that have no physical referents, for example law, retirement, inflation, and mind. Lyons (1977: 442–445) distinguishes three fundamental “orders”: (1) physical objects; (2) events, processes, states-of-affairs; and (3) propositions, schemas, etc. that “are outside space and time”.\(^6\) One of the main communicative uses of the abstract nouns in Lyons’s second and third orders is as “hidden variables” in causal explanations. For example, the sentence “the

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\(^5\) For a more precise definition, see Chapter 4 in Gärdenfors 2000.

economy is stagnating because the government cannot control inflation” expresses a causal relation between three abstract nouns.

Names can be seen as special cases of nouns. The difference is that names typically pick out a unique referent. If the basic communicative function of a noun is to express a referent and names identify a unique referent, why then does not everything have a name? It would seem that if every object had a name, this would eliminate many ambiguities. The reason why nouns are needed is one of cognitive economy (see for example, Kemp and Regier 2012). Our memory is severely constrained and it would be impossible to learn and remember a name for all objects one wants to communicate about. Nouns referring to basic-level categories group objects in categories that are suitably large for communication so that ambiguities become sufficiently rare. The cognitive solution is a balance between the precision of the noun and the number of words that have to be remembered.

6. Adjectives

My account of the semantics of adjectives will be based on my notion of properties. The key idea is that adjectives express properties. This generates the following thesis:

Single-domain thesis for adjectives: The meaning of an adjective can be represented as a convex region in a single domain.

For many adjectives, the single-domain thesis seems to be valid, in particular for adjectives that relate to domains that are acquired early in language learning. In particular, I conjectured (Gärdenfors 2000) that all colour terms in natural languages express convex regions with respect to the colour dimensions of hue, saturation, and brightness. This means, for example, that there should be no language that has a single word for the colours denoted by green and orange in English (and which includes no other colours), since such a word would represent two disjoint areas in the colour space. Strong support for this conjecture has been obtained by Jäger (2010).

Adjectives are also used for comparing things: Many languages have comparatives such as taller and smarter that can be used both as specifications (“the taller woman”) and predicatively (“Victoria is smarter than Oscar”). Many languages also have superlatives, for example, tallest and smartest, which again can be used as specifications and predicatively.

Nouns seldom allow comparisons (Schwarzschild 2008: 319): Expressions like *dogger, *more dog are hardly used. Why do nouns not allow comparatives, when adjectives do? A comparison requires a well-defined dimension along which the comparison is made. Since many adjectives are based on one-dimensional domains, a comparative (and a superlative) then simply involves a comparison of the values along this dimension: For example, “Oscar is taller than Victoria” means that Oscar’s coordinate on the length dimension is greater than that for Victoria.
If the adjective is based on a multidimensional domain, the situation becomes more complex. In general the comparative means “closer to the prototype for the adjective”: *Greener* means closer to the green prototype in colour space, *healthier* means lower value on some of the dimensions involved in illness.

Nouns refer to things and verbs say something about what happens to things. So why are there adjectives in language? Firstly, an adjective can be used as a specification of a noun (or noun phrase) that helps in identifying a referent. For example, if you want somebody to fetch you a particular book and there are several books present in the context, you specify it further by saying “the green book” or “the big book.” In addition to this kind of “element identification”, Frännhag (2010) also considers “kind identification”. For example, you may request “a thick book” when you want something to put on a chair for a child to sit on, but it does not matter which book is delivered. Here, the goal is not a particular object, but something that has a desired property.

Secondly, a typical function of an adjective is predicative. You can utter “The stove is hot” as a warning. Linguistically, the adjective is then a complement to a copula (“is”) or an intransitive verb (“the meal tastes wonderful”). The specification function and the predicative function may very well be cognitively separated. Therefore, it is not obvious that these functions should be expressed by only one word class. Dixon (2004: 30) notes that some languages indeed have two different word classes, one fulfilling the first function and another fulfilling the second. Actually, some words classified as adjectives in English only have one of the functions: *Afraid* and *alive* can only be used predicatively and *absolute* and *main* can only be used as specifications (attributively) (Paradis 2005). The specification function can also be fulfilled by a noun. For example “The silk scarf” can be used to distinguish among several scarves.

7. Verbs

In linguistics, the semantic role of verbs has been described as predication (for example, Croft 2001). However, the notion of predication is rather abstract—it derives from the Fregean view of language—and it does not capture the communicative role of verbs. Also within philosophy, there is recent criticism of the general use of predication (see e.g.

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7 There has been discussion as to whether there are languages without adjectives. For example it has been claimed that in Mandarin all adjectives are verbs. Dixon (2004) reviews the evidence and he concludes that something that has the role of modifiers can be found in all languages. He writes: “In some languages, adjectives have similar grammatical properties to nouns, in some to verbs, in some to both nouns and verbs, and in some to neither. I suggest that there are always some grammatical criteria—sometimes rather subtle—for distinguishing the adjective class from other classes” (Dixon 2004: 1).

8 Note that, in contrast to element identification, an indefinite determiner is used for kind identification.
Ben-Yami (2004) and McKay (2006)). Ben-Yami (2004: 142–143) points out that the common semantic content of what is called predication is minimal. He writes the following about Frege’s notion of predication:

*Ironically,* Frege was mislead into a mistaken view of concepts, [...] by what he time and again warned against: mistaking mere grammatical uniformity for a logical and semantic one. The semantic diversity of predication, acknowledged by logicians from Aristotle’s *Categories* on, disappeared under Frege’s pseudo-homogenous semantic relation of falling under a concept. (Ben-Yami 2004: 143)

Furthermore, adjectives are used predicatively too, so the notion does not characterize the use of verbs.

Verbs are necessary components in linguistic descriptions of *events*. Gärdenfors and Warglien (2012) and Warglien et al. (2012) describe events as complex structures built up from an *agent*, an *action*, a *patient*, and a *result*. Agents and patients are objects with different properties.9 It is assumed that the agent is able to act, which in the proposed framework amounts to exerting a force (Gärdenfors 2007, Gärdenfors and Warglien 2012).10 An action is modelled as a force vector (or a sequence of force vectors as in walking). The result of an event is modelled as a change vector representing the change of properties before and after the event. When the result vector is just a point, that is, when the result is no change, then the event is a *state*.

Elsewhere, I have proposed that when we describe an *event* at least one of the force and result vectors and at least one of the patient and the agent are part of the description (Warglien et al. (2012), Gärdenfors 2014). When describing an event, agents and patients are typically expressed by noun phrases and actions and results by verb phrases.11 Given this suggestion for event expressions, the model thus explains the linguistically basic distinction between nouns phrases and verb phrases. In contrast to mainstream linguistics, this distinction is made on a semantic basis derived from the cognitive representation of events.

Verbs cannot mean just anything. Kiparsky (1997) proposed that a verb can express inherently at most one semantic role, such as theme, instrument, direction, manner, or path. Rappaport Hovav and Levin (2010: 25) strengthened this by associating semantic roles with argument and modifier positions in an event schema, and proposed that ”a root can only be associated with one primitive predicate in an event schema, as either an argument or a modifier”. By using the cognitive notion of a domain, I can refine and strengthen the constraints proposed by Kiparsky and by Rappaport Hovav and Levin:

9 There exist events without agents such as event of falling, dying, and growing.
10 The force may also be "mental" or "social". See Warglien et al. (2012).
11 Languages also have other means of describing results of actions, for example by some generic verb such as “go” or “become” together with an adjective or a prepositional phrase.
Single-domain thesis for verbs: The meaning of a verb (verb root) is a convex region of vectors that depends only on a single domain. For example, push refers to the force vector of an event (and thus the force domain), move refers to changes in the spatial domain of the result vector and heat refers to changes in the temperature domain. The single-domain thesis for verbs is analogous to the single domain thesis for adjectives. The thesis entails that there are no verbs that mean ‘walk and burn’ (multiple domains) and there are no verbs that mean ‘crawl or run’ (not convex).

Since the model requires that an event always contains two vectors, the constraint entails that a single verb cannot completely describe an event, but only bring out an aspect of it. However, the two-vector model has the testable consequence that a construal can always be expanded to contain references to both the force and result vectors. More precisely, for any utterance based on a construal involving only a force vector, one can always meaningfully ask “What happened?”; and for any utterance based on a construal involving only a result vector one can always ask “How did it come about?”

According to the model, verbs have two main roles: (1) To describe what has happened (or will happen); and (2) to describe how it happened (or will happen). This is reflected linguistically by the distinction between result verbs, for example, run, hit, and wipe, and manner verbs, for example, fall, boil, and clean (Rappaport Hovav and Levin 2010; Warglien et. al 2012). A special case is when nothing happens, that is, when the event is a state. Verbs describing states such as stay, live and the most general is are all result verbs.

8. Prepositions

Adjectives modify a noun by specifying a property in a domain belonging to the object category that is referred to. Most prepositions can be grouped into two classes: locative, indicating where something is, and directional, indicating where something is going. Locative prepositions modify a noun (noun phrase) by specifying the location (a region) in the (visuo-)spatial domain: “Give me the bottle behind the bread!” Another function is fulfilled by directional prepositions. In a sentence such as “Oscar went to the library,” the phrase “to the library” has the same function as a result verb: it specifies the result vector of an event. Note that in both functions, the preposition is combined with a noun (or a noun phrase). My proposal is that locative prepositions are represented by convex sets of points and directional prepositions by convex sets of paths. In line with the analyses of the semantics of adjectives and verbs, I therefore put forward the following thesis:

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12 Possible exceptions to this general rule are verbs that describe changes in ontology (see section 4.4) and verbs like give that describe intentional actions involving recipients (see section 4.6). These are discussed in Gärdensfors (2014, Section 10.3.2).
Single-domain thesis for prepositions: Prepositions represent convex sets of points, paths or vectors in a single domain.

Locational and directional prepositions depend on the (visuo-)spatial relations. In order to model the meaning of prepositions I need to make some assumptions about how to model the spatial domain. Normally, this domain is represented with the aid of the Cartesian coordinates $x$, $y$, and $z$, representing ‘width’, ‘depth’, and ‘height’ and where distances are measured using a Euclidean metric. However, there is another way of representing space, namely in terms of polar coordinates that represent points in space in terms of distance and angles. A new definition of "between", and thereby convexity, that differs from standard Euclidean betweenness can be defined in terms of polar coordinates. For example the set of point of a semicircle convex points with respect to polar convexity (see Zwarts and Gärdenfors (2014) and Gärdenfors (2014, Ch. 11) concerning the technical details). Given this definition of convexity, it can be shown that most locative prepositions, such as inside, outside, near, far, in front of, and behind, can be represented by convex set of points.

Similarly, a betweenness relation for paths is easy to define and thereby convexity of sets of paths. On the basis of such a definition, it is easy to show that the meaning of directional prepositions, for example, to, from, into, out of, through, along, and across, correspond to convex sets of paths.

In contrast to most analyses within linguistics, I argue that prepositions do not only refer to the (visuo-)spatial domain. Some prepositions refer to the time domain. In English, the most common ones are before and after. In addition, most typical uses of the prepositions against, over, on and in depend on the force domain (see Vandeloise (1986) and Gärdenfors (2014, Ch. 11) for arguments).

In parallel to the theses for adjectives and verbs, the single-domain thesis for prepositions claims that each use of a preposition refers to a single domain, but it is not required that all uses are based on the same domain. What makes the thesis for prepositions a bit complicated is that there are frequent metaphorical transformations of meanings that bring prepositions that have the force domain as their basis into the (visuo-)spatial domain. And spatial prepositions are often used metaphorically for other domains. For example, in “Oscar came out of his depression”, the directional out of is used to refer to a path going from a state of depression to a non-depressed in the emotional domain. As a matter of fact, metaphorical uses of prepositions are ubiquitous. Nevertheless, I submit that for each preposition there is a central meaning that depends on a primary domain.

Historically, however, before and after referred to the spatial domain.

There are also “epistemic” prepositions such as despite, except, and regarding.
9. Adverbs

It is a challenge to describe the class of adverbs in semantic terms. There are very many kinds of adverbs, for example adverbs of manner, adverbs of frequency, adverbs of time, adverbs of place, adverbs of certainty. To some extent the adverbs form a leftover class: Adjectives modify nouns—adverbs modify everything else.

To give but one example of how adverbs are classified, Parsons (1990) divides them into speech-act modifiers, sentence modifiers, subject-oriented modifiers, verb phrase modifiers, and a remainder class. I cannot provide an analysis of all kinds of adverbs. As a complement to the semantics of verbs presented above, I will focus on adverbs modifying verbs (verb phrases).

In the semantic model of verbs presented in section 7, verbs refer to vectors. Vectors can vary in terms of dimension, orientation, and magnitude. Therefore, adverbs that are modifiers of verbs should refer to change in these features. For example, in “I speak slowly,” the adverb selects one of the several dimensions from the sound domain of speak. “I speak loudly” selects another. In “I walked backwards” the adverb refers to the orientation of my motion. Finally, in “He pushed the door softly,” the magnitude of the force vector representing push is diminished by the adverb. When an action involves a pattern of forces, adverbs can modify the whole pattern by providing dynamic information, for example “She walked limply”, “He smiled wryly”, or “She kicked aggressively”. What is common to these examples is that the adverb restricts the regions associated with the meanings of the manner verbs. Similarly, in relation to a result verb describing a concatenation of changes (as in a path), an adverb can provide information about the form the path takes, for example, “She crossed the park crookedly.” In brief, the function of adverbs modifying verbs is parallel to how adjectives modify nouns.

As long as adverbs function as multipliers (diminishers or magnifiers) within a particular domain, the convexity principle can be defended. For example, if certain voice volumes $v_1$ and $v_2$ both count as speaking loudly, then any volume between $v_1$ and $v_2$, will also count as loudly. And for adverbs expressing the form of a path, the principles of path convexity that were mentioned in section 8 will apply. It is an open question whether the convexity principle can also be applied to other adverbs.

Next, I turn to the domain specificity of adverbs. The structure of the domains underlying adjectives to some extent determines which adverbs can be combined with the adjective. For example, for scalar do-

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15 There are also interpretations of speak involving the communicative intentions (the illocutionary act) that involve more than the sound domain: “He spoke convincingly.”

16 Dixon (2004: 26) notes that in some languages adjectives also have adverbial function. Such a double function makes sense from the single-domain perspective.
mains with endpoints, there are “totality adverbs” such as completely, absolutely, and almost that mark nearness to an endpoint: completely full, almost ripe (Paradis 2001: 50–51). The totality adverbs do not combine with open-ended scalar domains: *completely long, *absolutely warm. Similar arguments can be applied to adverbs modifying verbs. In particular, force vectors have dimensions that are not shared by patient spaces representing results. The magnitude of force is peculiar to the force domain only and therefore adverbs expressing such magnitude, for example strongly, should apply to manner verbs (push strongly, hit strongly), but not to result verbs (*move strongly, *fall strongly, *break strongly). This principle functions well for manner verbs that are represented by a single force vector, for example contact verbs. For manner verbs that are represented by patterns of forces, however, the situation is less transparent (?walk strongly, ?swim strongly). While force magnitude is peculiar to manner, direction clearly is not. Hence modifiers expressing direction are generally shared by force and result vectors, for example ahead and left (push ahead, move ahead). On the other hand, some adverbs are tied to domains that are mainly associated with result verbs and thus they cannot be combined with manner verbs. For example, darkly relates to the light or the colour domain, but does not apply to the force domain (glimmer darkly, *push darkly, *hit darkly).

These considerations give some support for a thesis that that I formulate as a first approximation:

Thesis about adverbs: Verb-modifying adverbs refer to a single domain.

This thesis can be defended at least for adverbs functioning as multipliers. To what extent the thesis is more generally valid, also for other types of adverbs, remains to be further evaluated. One limitation of the more general thesis is that adverbs modifying adjectives (and other adverbs) can be zero-dimensional, for example, very and completely, and therefore cannot be associated with any domain.

10. Conclusion: The general single-domain thesis

In this article I have presented a semantic analysis of the major word classes based on conceptual spaces as a modelling tool. The observant reader has noticed that I have tried to argue for a general semantic rule:

Universal single-domain thesis: Words in all content word classes, except for nouns, refer to a single domain.

I am not certain how far I can push this thesis. To a large extent, its validity is dependent on how abstract domains are described. There are also word classes I have not considered, for example quantifiers and connectives, where the general single-domain thesis may not be valid or may not even apply. And I have noted that certain adverbs are zero-dimensional and thus not dependent on any domain.
Nevertheless, I want to put forward the thesis as a strong heuristic that language learners (implicitly) apply when learning the meaning of a new word. The default rule that if a newly encountered word is not a noun, then its meaning depends only on a single domain will simplify the acquisition of the meaning for the learner (cf. Bloom 2000, Chapter 8). In general, the syntactic markers of a word indicate its semantic role. Thus the markers help identify the relevant domain for the word. Lupyan and Dale (2010: 8) make “the paradoxical prediction that morphological overspecification, while clearly difficult for adults, facilitates infant language acquisition.” Mandler (2004: 281) argues along the same lines:

Many of the grammatical aspects of language seem impossibly abstract for the very young child to master. But when the concepts that underlie them are analyzed in terms of notions that children have already conceptualized, not only does the linguistic problem facing the child seem more tractable but also the types of errors that are made become more predictable. The invention of grammatical forms to express conceptual notions that are salient in a young child’s conceptualization of events seems especially informative.

Since the relevant domain is often determined by the communicative context in which the word is uttered, applying the single-domain thesis will make the identification of the new meaning much more efficient. Thus I propose that a general single-domain bias provides one of the fundamental reasons why humans can learn a language as quickly as they do.17

References

17 Even though I cannot present any detailed argumentation here, I believe that the principles of language learning that have been discussed here offer a way out of Chomsky’s (1980) “poverty of stimulus” argument. Children do not learn the grammar of a language independently of its semantics. The semantic constraints presented in this book will considerably narrow down the possible syntactic systems.


